CHALLENGES TO CONSUMERS PRACTICES TOWARD RENEWABLE ENERGY IN HOUSEHOLD FROM A SOCIO-TECHNICAL PERSPECTIVE

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DEDICATION

To Mak & Abah,
The strong and gentle souls who taught me to trust in Allah SWT, believe in hard work and never give up !

To my supervisor,
His contribution and guidance has raised the quality of this thesis. He always supported me and have given me enthusiasm for research. He have patiently guided me. I am very grateful to his supervision and I owe him the greatest degree of appreciation.

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May we be successful educators in the future, insyaAllah Amiin.

To my siblings and coolzens,
Thanks for trusting and loving me, yeah that's all enough to keep me going ☺

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ABSTRACT

Energy has always been a major source of human beings and has depended on it for survival and productive activities. Conventional energy sources (eg: fossil fuel) will cause pollution, and their use will degrade the environment but renewable energy is environmentally friendly. However, social acceptance of renewable energy has been challenging because of cheaper alternative energy. The objective of this research is to identify the perception among Malaysian households towards renewable energy and to investigate social and technical challenges that influence consumer intention to use renewable energy in households. This study used the questionnaire method to collect quantitative data. The respondents were Malaysian households. Questionnaires collected were 375 (63%), but only 367 (61%) questionnaire sets were considered valid for further analysis. The data were analysed using Statistical Package for Social Science (SPSS) and Partial Least Square Structural Equation Modeling (PLS-SEM). The findings provide a deeper understanding of the consumer intention to use renewable energy in households by combining socio-technical perspectives (Facilitating Technical Conditions, Perceived System Quality, Social Trust and Social Support) with the TPB model (Attitude, Subjective Norm, Perceived Behavioral Control and Intention). The extended TPB model was tested using PLS-SEM. The findings revealed that attitude is the best predictor of intention to use renewable energy in the household. Subjective norm also has a significant predictive ability. However, perceived behavioural control is not a significant variable in predicting the intention to use renewable energy in the household. Meanwhile, technical conditions and social support are the challenges factors which can influence consumer intention to use renewable energy in households. In conclusion, Malaysian people are not ready yet to become renewable energy systems practitioners due to negative perceived behavioural control and subjective norm towards intention to use renewable energy in the household.

ABSTRAK

Tenaga adalah sumber utama dan manusia bergantung kepadanya untuk meneruskan hidup dan menjalani aktiviti yang produktif. Sumber tenaga konvensional (seperti: bahan api fosil) menyebabkan pencemaran, manakala tenaga boleh diperbaharui adalah mesra alam. Tetapi, penerimaan sosial terhadap tenaga boleh diperbaharui adalah mencabar kerana tenaga alternatif yang lebih murah. Objektif penyelidikan adalah mengenalpasti persepsi rakyat Malaysia terhadap tenaga boleh diperbaharui di rumah dan menyiasat faktor cabaran sosial dan teknikal yang mempengaruhi niat pengguna untuk mengamalkan tenaga boleh diperbaharui dalam isi rumah. Kajian ini menggunakan kaedah soal selidik untuk data kuantitatif. Responden adalah rakyat Malaysia. Sebanyak 375 (63%) soal selidik telah dikumpulkan, tetapi hanya 367 (61%) set soal selidik dianggap sah untuk analisis selanjutnya. Data ini dianalisis dengan menggunakan *Statistical Package for Social Science (SPSS)* dan *Partial Least Square Structural Equation Modeling (PLS-SEM).* Hasil kajian memberikan kefahaman tentang niat pengguna untuk tenaga boleh diperbaharui di rumah dengan perspektif sosio-teknikal yang menggabungkan (*Facilitating Technical Conditions, Perceived System Quality, Social Trust* dan *Social Suppor*t) dengan model TPB (*Attitude, Subjective Norm, Perceived Behavioral Control* dan *Intention*), kemudian diuji menggunakan PLS-SEM. Melalui hasil kajian, *attitude* dan *subjective norm* adalah faktor utama yang mempengaruhi *intention* mengamalkan sistem tenaga boleh diperbaharui di rumah. Manakala, *perceived behavioral control* adalah faktor yang kurang mempengaruhi *intention* mengamalkan sistem tenaga boleh diperbaharui di rumah. Kemudian, *technical conditions* dan *social suppor*t adalah faktor cabaran yang mempengaruhi niat pengguna untuk mengamalkan tenaga boleh diperbaharui di rumah. Sebagai kesimpulan, rakyat Malaysia belum bersedia untuk menjadi pengamal sistem tenaga boleh diperbaharui kerana *perceived behavioral control* dan *subjective norm* adalah negatif terhadap *intention*.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Energy has always been a major source of human beings and has depended on it for survival and productive activities. Energy is known as the catalyst for development and important element to support the population growth, urbanization, industrialization and tourism industry (Karakosta, Pappas, Marinakis, & Psarras, 2013). Energy is needed to maintain and improve the quality of life. The dramatic societal change and population growth since the industrial revolution have required a large amount of energy provided primarily by coal and petroleum (Hall *et al.*, 2003). Industrial and technological advances in modern society were also achieved through energy efficiency. There is a strong correlation between quality of life and energy consumption. From Pasten & Santamarina (2012), a significant improvement in the quality of life can be achieved with a limited impact on energy demand in all countries, particularly in developing countries.

With the rapid growth of energy demand and consumption, problems concerning energy, environment and climate changes are becoming increasingly prominent. Countries in the world are looking for a way of harmonious development of society, economy, resources and environment (Guta, 2014; Tang & Liao, 2014; Yuan & Zhao, 2014). Energy conservation, energy efficiency and use of renewable energy could reduce fossil energy consumption efficiently. This is good for ecological and environmental protection, reduction of global warming and

collaborative promotion of sustainable social development (Debnath, Mourshed, & Chew, 2015; Li *et al.*, 2007; Mazzola, Astolfi, & Macchi, 2016; Zhou *et al.*, 2009). Search for new sources of energy to reduce the threat of climate change is becoming urgent matters. New knowledge and technologies have emerged, and the race is on for the best option. In the near future, further population growth and improvement in the quality of life will increase the demand for non-renewable fossil fuels (coal, natural gas, and petroleum) and increasing environmental implications (IPCC, 2007; Lee, 2011). A reliance on oil imports could have a deeper impact on developing countries than developed ones because the economy in the developing countries are depending on the economic sources which then sourced to important areas for improvement such as food, employment and security (Cutz, Haro, Santana, & Johnsson, 2016).

Green and alternative energy technologies are useful concepts that have emerged from the growing need of energy. To maintain the ecological balance of this planet, a major invention has been to motivate the users towards renewable energy technologies. Social, regulatory and technical know-how are the three major problems that hinder the process of conversion to alternative energy (Wüstenhagen, Wolsink, & Bürer, 2007). Studies on alternative energy in developed country examine users' attitude towards renewable energy in order to understand the barriers embedded in the socialisation of renewable energy (Alam *et al*., 2014; Mallett, 2007; Richards *et al*., 2012; Stephenson, & Loannou, 2010; Zografakis *et al*., 2010).

Buildings are increasingly the key to decarbonising the environment. Improvements to the energy efficiency of building systems are the primary means intended for such decarbonisation (De Boeck, Verbeke, & Audenaert, 2013; Xing, Hewitt, & Griffith, 2011). However, in existing buildings, renewable heating, cooling and power are likely to play an important complementary role to energy efficiency in bringing buildings closer to net-zero energy or carbon status (Cellura *et al.*, 2015; Deng, Wang, & Dai, 2014) given the fact that the building stock is very long-lived (IEA, 2013), whereas building systems have shorter life spans and are thus renewed more rapidly (Kranzl, Müller, Kockat, Steinbach, & Toleikyte, 2015). As a result, the adoption of new heating, cooling and power production technologies in the building is of increasing interest for both policy makers and companies marketing renewable energy solutions for buildings.

There is no doubt that current energy consumption causes global problems. Burning fossil fuels causes greenhouse gas emissions resulting in global warming and the use of nuclear power leaves the question of permanent waste disposal (Kastner & Stern, 2015). These problems can be overcome in two ways: reducing energy consumption and shifting energy provision toward renewable sources. Ideally, both approaches should be pursued at the same time. Promising technological progress has been made in both areas. Energy efficiency of technical devices increases and renewable energy systems improve constantly. There is still a fundamental "human factor", when it comes to energy consumption. In the end, people decide about consumption and about whether or not to adopt new technology. Thus, several researchers demand that social and behavioural science should be better integrated in energy research (Sovacool, 2014) So, the question about the implications of consumer behaviour in renewable energy technologies is remained here. Hence, the problem statement associated with the consumer behaviour in the renewable energy technologies would be addressed in the next section.

1.2 Problem Statements

Sources of non-renewable energy soon will finish and diminish. Therefore, it is time that some renewable energy sources is extracted and used to generate a lot of energy that we need. Demand for energy is increasing every year due to rapid industrialization and population growth, and the conventional energy resources will not be sufficient enough to meet this growing demand. The International Energy Agency (IEA) in its New Policies Scenario predicts that global energy demand will rise by approximately one-third from now until 2035, with the majority of that demand coming from China, India, ASEAN countries and the Middle East (International Energy Agency, 2014; Oh, Pang, & Chua, 2010). The increase is largely caused by energy derived from non-renewable fuel sources (International Energy Agency, 2010).

Many studies in the world showed that household causes negative impact to the environment. In Europe, energy consumption in the households are more than transportation and other industry (European Commission, 2015), which proves that

household is the major contributors to climate change because of the release of carbon dioxide and others greenhouses gases. Since then, energy efficiency in the household has been the focus of worldwide research (Marique *et al.*, 2017). Since past decades, the expanding development of economy and society has resulted high demand in energy, which household energy consumption is one of a significant proportion (Ouyang & Hokao, 2009; Song *et al.*, 2013; Wang *et al.*, 2011; Zhou *et al.*, 2015). Hence, household energy consumption has causes serious environmental problems.

Past studies also confirmed that household is a major consumer of energy. Since last few decades, electricity consumption has been increased, especially in the service and residential sectors. The increased ownership and usage of electrical appliances are the main causes of this rise (Gaspar & Autunes, 2011; Taylor *et al.*, 2010). Meanwhile, from 2004 to 2014 in Malaysia, the residential sector showed high growth rate of household electricity consumption (Tan, Ooi, & Goh, 2017). Thus, household is the important contributor in high electricity consumption based on their usage of household energy appliances. Statistics from Energy Commission showed that Malaysian households consumed about 20% of total electricity usage in 2011, increased from 18% in 2007. The rise of electricity consumption in Malaysia led to concern of the Malaysian government because increasing in energy consumption causes carbon dioxide emission (Energy Commission, 2016).

The production, distribution and use of energy, particularly fossil fuels have significant environmental impacts, even in Malaysia (Petinrin & Shaaban, 2015). From the statistics released by World Health Organization (WHO), indirect and direct impacts of climate change have led to 160,000 deaths each year and is estimated to double the rate by 2020 (S. Mekhilef, Saidur, & Safari, 2011). Thus, conventional energy sources, such as fossil fuel will cause pollution, and therefore, their use will degrades the environment but renewable energy is environmentally friendly.

The main challenge facing the world today is due to the energy supply, distribution of energy resources, and high energy prices. Malaysia is no exception to this problem. The growing consumption of energy has resulted in Malaysia becoming increasingly dependent on fossil fuels (Petinrin & Shaaban, 2015). This situation is very uncertain it emphasizes the need to diversify our dependence on a few sources of fuel. The increase in oil and gas prices and the lack of their potential

in future lead to concern about the availability of energy supply needed to sustain the economic growth. Therefore, the search for alternative fuels such as renewable energy resources has become important (Dwivedi, Jain, & Sharma, 2011).

Therefore, the increase in energy consumption, the uncertainty market price of conventional fuel and global climate change explain the urgent need for greener solutions for replacing large-scale power generation plant and produce reliable power. Efforts to reduce emissions should complement a commendable public policy to move the country away from dependence on a single energy source (Umar, Jennings, & Urmee, 2014). Meanwhile, Malaysia is 34% more energy intensive than other neighbouring countries and this indicates the need for a more balanced and diversified supply and demand side energy management (Umar *et al*., 2014).

Thus, there are two issues for this research. The first issue is social acceptance of renewable energy has been challenging for many users because of their cheaper alternative energy. Apart from purely social fortune, households tendency towards new technology adoption is highly process oriented and a long-term dispute because investment in renewable energy is expensive (Jacobsson & Johnson, 2000; Sahin & Rogers, 2006; Straub, 2009). New users only like to increase their energy budget not more than 5% in many developed countries (Dalton, Lockington, & Baldock, 2008; Zografakis *et al*., 2010). It is still at the primary stage to comment on the success of the retail channels to make renewable energy available to mass consumers. In addition, consumer lifestyle, level of awareness and ease of technology use are factors which influence rapid acceptance of renewable energy (Faiers & Neame, 2006).

Besides, there is an urgent need to reduce energy uses in our residential and promoting energy efficiency in households is seen as a good approach to the reduce of climate change (Marique *et al*., 2017). To reduce the energy and environmental problems caused by household energy use, many research and development (R&D) efforts on energy efficient technologies have been made (Allcott & Mullainathan, 2010). Other than the economic concerns, issues like values, household activities, acquired technologies, and everyday life routines are also important factors led to intention to use renewable energy technologies (Aune *et al*., 2016). Hence, many of the concerns of the other approaches take on board. Household energy consumption can also be understood through interactions between norms, attitudes, material

objects, and energy practices (Aune *et al*., 2016). So, this will be the second issues for this research.

The most promising efforts to reduce environmental pressures and climate change is by improving energy efficiency and reducing energy demand (Sorrell, 2015). Besides that, behavioural are great factors too in achieving energy conservation (Sovacool, 2014; Kaile Zhou & Yang, 2016). Thus, many behavioural and psychological models of consumers have been developed and adopted in the past researches to explore householders' energy consumption behaviour and its influencing factors (Ajzen, 1991; Jackson, 2005; Vining *et al.*, 2003). Besides that, factors affecting the implementation of energy efficiency household appliances may not be clearly understood by policy makers and by the producers and suppliers of such household appliances (Tan *et al*., 2017). It is important for the marketers and policy makers to understand the effect of some key factors which affected the intention to use renewable energy technologies in households.

Large numbers of studies have been done on energy conservation and energy efficiency over the past few globally. Among those studies, only a handful focused particularly on determinants of purchase intention for energy-efficient appliances or renewable energy technologies (Tan *et al*., 2017). Studies on renewable energy in Malaysia are widely covering the technical and regulatory advancements of new technology for mass use as in table 1.1. But, studies on social barriers and consumers' attitude towards renewable energy are yet to emerge in public domain. Therefore, consumers' experience with and their attitude towards renewable energy is yet to be rightly explored.

Table 1.1: A Summary of Studies on Renewable Energy in Malaysia

Authors	Topic
(Tan *et al*., 2017)	Extension of the theory of planned behavior to predict consumers' purchase intention for energy-efficient household appliances in Malaysia
(Sovacool & Bulan, 2012)	Energy and hydropower development in Sarawak.
(Ong, Mahlia, & Masjuki, 2012)	Energy pattern and policy for transportation sector in Malaysia.
(S. Mekhilef et al., 2012)	Current state and prospects of solar energy in Malaysia.
(Chua & Oh, 2012)	Solar energy outlook in Malaysia.
(Tye *et al.*, 2011)	Bioethanol as an energy source in Malaysia.
(Sovacool & Drupady, 2011)	Small renewable energy power program in Malaysia.

(Mohammed *et al*., 2011)	Hydrogen rick gas from palm oil biomass as a potential renewable energy in Malaysia.
(Poh, & Kong, 2002)	A policy analysis for renewable energy in Malaysia.
(Dalimin, 1995)	Renewable energy update in Malaysia.

1.3 Research Questions

Based on the problem statement, some research questions had been developed through this study.

a) What is the perception among Malaysian toward renewable energy in households?
b) Which social and technical challenges factors influence consumer intention to practice renewable energy in households?

1.4 Research Objectives

Research objectives that have been outlined are;

i. To investigate the perception among Malaysian toward renewable energy in households
ii. To investigate social and technical challenges factors influence consumer intention to practice renewable energy in households

1.5 Scope of Study

To meet the research objectives, scope of the study includes aspects of the research as described:

- Both objectives of this study using the questionnaire to obtain the accurate information about renewable energy consumerism in Malaysia. This research distribute questionnaire to the respondents using Google Drive and by hand.

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